

## **Cardiac Arrhythmias**

**ILOs: By the end of this lecture the student will be able to:**

1. Define and classify arrhythmia based on its origin.
  2. List 2 mechanisms for tachyarrhythmias.
  3. Describe the ECG changes in different types of arrhythmias.
  4. Compare & contrast atrial flutter & fibrillation.
  5. Mention the ECG findings in second degree heart block.
- In the normal human heart, each beat originates in the SA node then passes in the normal conductive pathway to activate the atria and then the ventricles (**normal sinus rhythm, NSR**). The heart beats about 60-100 (average 70) times a minute at rest.
- The ECG picture of the normal sinus rhythm: normal P wave, P-R interval of normal duration, QRS of normal duration and configuration and normal T wave in the direction parallel to the QRS complex.

### **Cardiac arrhythmias:**

Disturbance in either rate, or regularity of the normal cardiac rhythm i.e abnormal rhythm of the heart.

There are numerous types of arrhythmia, some are negligible, but some may cause palpitations, syncope, heart failure, dizziness & sudden death.

### **Classification of cardiac arrhythmias:**

#### **I. Arrhythmias due to disturbance in impulse formation:**

**1.Alteration in SA node activity (sinus arrhythmia):**

- Sinus tachycardia.
- Sinus bradycardia.

**2. AV nodal rhythm.**

**3.Ectopic beats (extrasystoles):**

- *Supraventricular*: premature atrial contraction (PAC).
- *Ventricular*: premature ventricular contraction (PVC)

**4.Ectopic tachycardias:**

- ***Supraventricular tachycardias***:
  - Paroxysmal Atrial Tachycardia (PAT)
  - Atrial Flutter
  - Atrial Fibrillation (AF)
- ***Ventricular tachycardias***:
  - Paroxysmal Ventricular Tachycardia (PVT)
  - Ventricular Fibrillation (VF)

**II. Arrhythmias due to disturbance in impulse conduction:**

**1.Accelerated AV conduction "*Wolf-Parkinson-White (WPW) Syndrome*".**

**2.Conduction block:**

- ***Atrioventricular block (AV heart block)***.
  - a. 1st degree.
  - b. 2nd degree.
  - c. 3rd degree.
- ***Bundle Branch Block (BBB)***.

**Arrhythmias due to disturbance in**

## **1. Alteration in SA node activity (sinus arrhythmia):**

The SA node is still the only pacemaker, but there is a change in the rate of its discharge under the effect of cardiac autonomic nerves.

### **Sinus Tachycardia**

- The term "tachycardia" means *fast heart rate*, usually defined in an adult person as faster than **100 beats/min**. In sinus tachycardia the SA node fires **faster** than normal + impulse is conducted normally.
- An electrocardiogram recorded from a patient with sinus tachycardia is shown in Figure 1. This electrocardiogram is normal except that the heart rate, as determined from the time intervals between QRS complexes (duration of cardiac cycle) is shortened.
- Some **causes** of sinus tachycardia include stress, emotions and exercise (increased sympathetic activity), regulation of lowered arterial blood pressure as in case of hemorrhage., fever, hyperthyroidism (increased metabolism of SA node by excess thyroxine hormone), drugs (e.g adrenaline, atropine).

**Figure (1): Sinus tachycardia**



### **Sinus Bradycardia**

- The term "bradycardia" means a slow heart rate, usually defined as fewer than **60 beats/min**. SA node fires **slower** than normal + impulse is conducted normally.

- An electrocardiogram recorded from a patient with sinus bradycardia is shown in Figure 2. This electrocardiogram is normal except that the heart rate, as determined from the time intervals between QRS complexes (duration of cardiac cycle) is prolonged.
- Some **causes** of sinus bradycardia include sleep and in athletes (increased vagal tone), regulation of increased arterial blood, hypothyroidism, drugs ( $\beta$ - blockers &

**Figure (2): Sinus bradycardia**



digitalis).

## **2.AV nodal rhythm (junctional rhythm):**

- If the SA node is damaged or depressed, the AV node may function as escape pacemaker and beat at an average rate of 40-60 beat/minute.
- An electrocardiogram recorded from a patient with AV nodal rhythm is shown in Figure 3. The ECG findings are
  - a. Inverted P wave, because atria are stimulated in retrograde fashion from bottom to top.
  - b. Short P-R interval, because the pacemaker became closer to the ventricle than the SA node.

- c. Normal QRS complex and T wave, because the ventricles were stimulated through the normal pathway.

**Figure (3): AV nodal rhythm**



### **What is meant by an ectopic focus?**

- ✓ It is an area of the heart that initiates an impulse without waiting for the SA node.
- ✓ If the ectopic focus fires **once**, the result is a beat that occurs before the expected next normal beat and transiently interrupt the cardiac rhythm → **premature beat (extrasystole)**.
- ✓ If the ectopic focus fires **repetitively** + higher than the SA node → a sustained abnormal rhythm (**paroxysmal tachycardia**).
- ✓ Ectopic foci can occur in both healthy & diseased hearts.
- ✓ **Ectopic foci can occur in**
  - 1- the AV node & other parts of the His Purkinje system and become the pace maker of the heart.
  - 2- atrial & ventricular muscle fibers (non-pacemaker tissues) in abnormal conditions e.g cardiac ischemia.

### **3.Ectopic beats (extrasystoles):**

- Early abnormal systole produced by impulse discharged once from an ectopic focus during diastole (as the cardiac

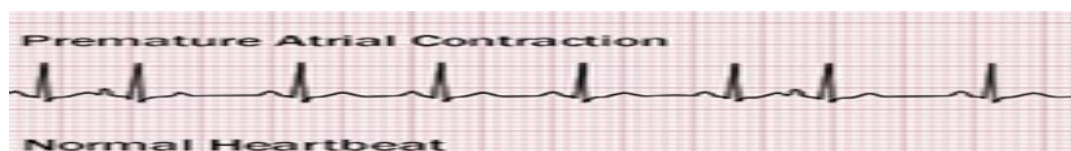
muscle during systole is in the ARP). So, it is a contraction of the heart prior to the time of the expected normal contraction of the heart.

- It can occur physiologically in stress, smoking, excessive caffeine intake and during pregnancy and pathologically in myocardial ischemia.
- Premature contractions are of the following types:
  - a. *Supraventricular*: premature atrial contraction (PAC).
  - b. *Ventricular*: premature ventricular contraction (PVC)

### **Premature Atrial Contraction (PAC)**

- The excitation wave which is discharged from the atrial ectopic focus stimulates the AV node prematurely, and is conducted to the ventricles through the normal AV pathway. The pulse wave produced by the premature contraction may be so weak that the pulse cannot be felt at all in the radial artery.
- The ECG findings of PACs are shown in Figure (4):
  - a. P waves are abnormal as the atria are stimulated from an ectopic focus in the atria, not SA node.
  - b. P-R interval is shortened, because usually the beat originates near to the AV node. May be followed by a compensatory pause i.e the interval between the premature contraction and the next contraction is slightly prolonged.
  - c. QRS complex and T waves are normal.

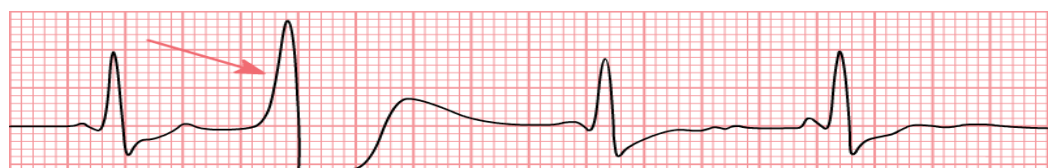
**Figure (4): Premature atrial beat compared to a normal heart beat**



## **Premature Ventricular Contraction (PVC)**

- In PVCs, the hyperexcitable ectopic focus develops in the ventricles.
- The ECG findings of PACs are shown in Figure (5):
  - a.** P wave is absent: as no retrograde conduction to the atria.
  - b.** QRS complex is wide, prolonged ( $> 0.12$ ) (bizarre shape) & of high voltage: because of the spread of the impulse from the focus through the ventricular muscle to the rest of the ventricles, rather than through the Purkinje system.
  - c.** T-wave is inverted: because the slow conduction of impulse in the cardiac muscle causes the area first depolarize also to repolarize first.
  - d.** In PVC, the compensatory pause is more common because following PVC, the next atrial impulse arrives while the AV node is still refractory and, therefore, is not conducted to the ventricles, creating a pause in the ventricular rhythm. Thus, PVC results in a disturbed cardiac rhythm that can be detected by palpation with the premature beat weaker, and the following beat usually more delayed and stronger than normal due to the strength-interval relationship together with the added stroke volume.

**Figure (5): Premature Ventricular Contraction**



#### **4. Ectopic tachycardias:**

- If the ectopic focus discharges repetitively at a rate higher than that of the SA node, it produces rapid regular tachycardias (atrial or ventricular paroxysmal tachycardia). Tachycardias originating from ectopic foci (atrial or ventricular) are in the form of sudden attacks (episodes or paroxysms) of rapid regular tachycardia. These episodes usually start suddenly, last for a while and then stop quickly, persist for few beats, for many hours or days, so is often called "paroxysmal tachycardia".
- ***Causes of ectopic tachycardias:***
  1. The rapid firing of an ectopic pacemaker, due to enhanced automaticity, overdriving the SA node and taking over control of the heart rate. (less common)
  2. Reentry phenomenon and circus movement. (more common)
- Ectopic tachycardias include:
  - a. Supraventricular tachycardias:***
    - Paroxysmal Atrial Tachycardia (PAT)
    - Atrial Flutter
    - Atrial Fibrillation (AF)
  - b. Ventricular tachycardias:***
    - Paroxysmal Ventricular Tachycardia (PVT)
    - Ventricular Fibrillation (VF)

#### **Paroxysmal Atrial Tachycardia (PAT)**

- PAT is characterized by very regular rates of 150 - 220 bpm. It has a very rapid onset, and its duration is usually

some seconds or few minutes, although occasionally it may last for hours or days.

- The ECG findings of PAT are shown in Figure (8):
  - a. P wave: are usually abnormal due to their ectopic origin, and, because of the rapid cardiac rate, they are sometimes difficult to identify.
  - b. QRS and T waves are normal because ventricular conduction is normal.

**Figure (8): Paroxysmal atrial tachycardia**

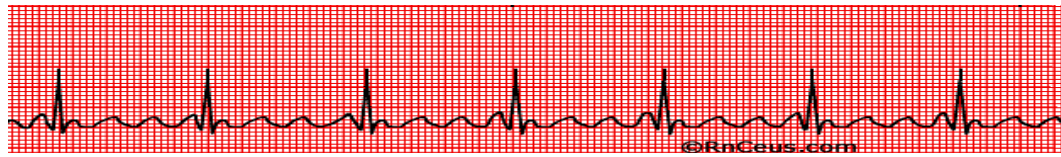


### **Atrial flutter**

- In atrial flutter, single atrial ectopic focus or reentry mechanism causes the atria to fire at a regular rate of about 250-350 bpm. At these rapid rates, AV node and ventricular tissues may not be able to respond to each depolarization. As a result, a physiologic AV block may be present and the ventricular rate will be 125-175 bpm.
- Atrial contraction is synchronous so, the pumping during atrial systole is efficient and its contribution to ventricular filling is appropriate with rather normal cardiac output.
- An electrocardiogram recorded from a patient with atrial flutter is shown in Figure (9): The ECG findings are
  - a. P wave is abnormal in shape, and is repeated in a regular closely spaced series, called **flutter waves**.
  - b. QRS complex and T wave are normal, since the pacemaker is in the atrium; conduction to the ventricles is via the regular pathway.

- c. There are 2 or 3 P waves for every QRS complex. 2: 1 or 3: 1 rhythm.

**Figure (9): Atrial flutter**



### **Atrial Fibrillation (AF)**

- In atrial fibrillation, multiple ectopic foci in the atrium that discharge rapidly and irregularly at a rate, of 350 - 500bpm. A varying degree of heart block occurs in AV node, so the ventricular rate is in the range of 100 - 150 bpm. Because of this rapid irregular electric activity, the atria lose their ability to contract in a synchronous pattern. The irregular contraction of individual myocardial fibers has been described as a "bag of worms" with no effective atrial contraction or pumping with no contribution of atrial systole in filling of the ventricles, leading to decrease in cardiac output.
- An electrocardiogram recorded from a patient with atrial fibrillation is shown in Figure (10): The ECG findings are
  - a. P wave: absent and replaced by F waves which appear as an irregular undulation of the base line.
  - b. QRS complex and T wave are of normal configuration & are very irregularly spaced (variable R-R interval).

**Figure (10): Atrial Fibrillation**



### **Paroxysmal Ventricular Tachycardia (PVT)**

- An ectopic ventricular focus causes a ventricular tachycardia in the form of a series of ventricular premature beats occurring one after another without any normal beats in-between. The ventricular rate usually varies between 150 and 250 bpm or slower. The reentry mechanism appears to be of particular importance in the production of ventricular tachycardia (PVT).
- Cardiac output is reduced due to decreased filling time and power of contraction. It is usually a serious condition that occurs due to ischemic damage, and may initiate ventricular fibrillation.
- An electrocardiogram recorded from a patient with paroxysmal ventricular tachycardia is shown in Figure (11): The ECG findings are
  - a. P waves is absent (hidden in the more frequent QRS).
  - b. The QRS complexes are slurred, notched, and wide (bizarre) because of abnormal conduction in the ventricles.

**Figure (11): Paroxysmal ventricular tachycardia**



### **Ventricular Fibrillation (VF)**

- Ventricular fibrillation is a serious condition that lead to death within a few minutes unless emergency treatment is initiated and the normal cardiac rhythm is restored. It

may be triggered by such events as myocardial ischemia or an ectopic ventricular pacemaker. In fact, ventricular fibrillation represents the most frequent cause of sudden death in patients with myocardial infarction.

- The fibrillating ventricles cannot pump blood effectively, and circulation of the blood stops (irregular and ineffective twitching movement & the fibrillating ventricle, look like a quivering "bag of worms"). The peripheral pulse is absent, and the cardiac output falls to zero.
- An electrocardiogram recorded from a patient with ventricular fibrillation is shown in Figure (12): bizarre irregular patterns of rapid ECG deflections, showing undulating waves of varying frequency and amplitude, without any distinguishable rhythm due to the uncoordinated electric activity of the ventricles.

**Figure (12): Ventricular Fibrillation**



## **Arrhythmias due to disturbance in**

### ***Atrioventricular block (AV heart block):***

*There are 3 degrees of AV heart block:*

#### **1- First degree AV block:**

There is delay of conduction from the atria to the ventricles but not actual blockage of conduction. Every atrial beat is followed by a ventricular beat

An electrocardiogram recorded from a patient with 1<sup>st</sup> degree heart block is shown in Figure (13): The P-R interval increase above 0.21 sec, the ratio of P: QRS is 1:1. P wave, QRS complex and T wave are normal.

Figure (13): First degree heart block



### **Second degree (incomplete) AV block:**

Type (1): P-R Interval lengthens progressively until a ventricular beat is dropped. The next beat shows a normal duration of P-R interval which progressively lengthen again and so on. An electrocardiogram recorded from a patient with 2<sup>nd</sup> degree heart block, type (1) is shown in Figure (14a):

Figure (14a): second degree heart block (type1)



Type (2): Not all atrial impulses are transmitted to the ventricle. The atria beat at a faster rate than the ventricles giving rise to dropped beats. This means that there is a ventricular beat following every second or every third atrial beat (2:1 or 3:1 block). An electrocardiogram recorded from a patient with 2<sup>nd</sup> degree heart block, type (2) is shown in Figure (14b): the ratio of P: QRS is 2:1 or 3:1. P wave, QRS complex and T wave are all normal.

Figure (14b): Second degree heart block (type 2)



### **Third degree (Complete) AV block:**

There is complete block of impulse conduction from atria into ventricles. There is no relationship between the rhythm of the atria and that of the ventricles. The atria beat at an average rate of 70 bpm (normal sinus rhythm), while the ventricles beat at a low rate average 25-45 bpm (idioventricular rhythm). Sometimes this rhythm may be as slow as 15-20 bpm resulting in periods of asystole with resultant cerebral ischemia causing dizziness and fainting (Stock-Adams Syndrome).

An electrocardiogram recorded from a patient with 3<sup>rd</sup> degree heart block is shown in Figure (15): The P wave becomes completely dissociated from the QRS complex. So, the P waves may fall before, on or after the QRS complexes.

Figure (15): Third degree heart block

